Modeling Reservoirs in NWSRFS

Overview

OBJECTIVES

- General overview of available reservoir models
  - Major Features
  - Data requirements
  - Model input
  - Use Criteria
- Side by side model comparison
- Setting up and Running Reservoir models

Available reservoir models

- RES-SNGL
- SSARRESV Streamflow Synthesis and Reservoir Regulation System
- RES-J
- FLDWAV

RES-SNGL Operation Description and Features

- Simulation of a single independently operated reservoir.
- Uses Schemes and Utilities to model reservoir physics
- Uses Reservoir Command Language (RCL) to control reservoir operation
- Models fairly sophisticated operating rules
- Requires little run-time interaction
- Some run-time control available
- Long implementation process

RES-SNGL Data Requirements

- Minimum Input
  - Elevation storage curve
  - Time series
    - Instantaneous inflow
    - Mean inflow
  - Carryover
    - Instantaneous inflow and pool elevation at start of run
  - RCL -- At least one scheme
- Additional Input
  - Data needed for schemes/utilities to be used
  - Instructions on when schemes and certain utilities should be used (RCL)

RES-SNGL Operation Input

- There are 3 sections used to define RES-SNGL parameters
  - General section: used to define elevation storage curve, units (English, SI), title, description, carryover, time series to be used.
  - Specific section: used to define parameters for schemes and utilities.
  - RCL section: used to define constraints on scheme execution so the model knows when to execute a particular scheme. Constraints may be based on flow, elevation, or storage characteristics as well as day of year.

RES-SNGL SCHEMES AND UTILITIES

- Computational Schemes (Generates Output)
  - PASSFLOW
  - SETQ
  - SETH
  - SETDQ
  - RULECURVE
  - FILLSPILL
  - SPILLWAY
  - POOLQ
  - STPOOLQ
  - MINQ
  - MINH
  - INDSRCHGE
  - FLASSBDS
  - POWERGEN
- Utilities (Simulation Aid)
  - RULEADJ
  - SUMINF
  - RAINEVAP
  - ADJUST
  - BACKFLOW
  - MAXQ
  - ENTERISC
  - SETMIN
  - SETMAX
  - GOFLASH

Use RES-SNGL Operation

- Modeling a single reservoir
- Operation rules are known
- No backwater effects except on power generation
- Requires sophisticated operation such as power generation, flash board, and induced surcharge etc.
- Short or long term forecasts

SSARRESV Operation Description

- Based on the Streamflow Synthesis and Reservoir Regulation System developed by U. S. Army Corps of Engineers and NWRFC.
- The operation routes streamflow from upstream to downstream points through lake storage and reservoirs under free flow or controlled-flow modes of operation.
- Flows may be routed as a function of multivariable relationships involving backwater effects from a downstream reservoir.

SSARRESV Operation Features

- Models single reservoir with or without backwater effect
- Models 2 reservoir system with or without backwater effects
- Regulates downstream reservoir to achieve desired flow condition at upstream station.
- Doesn't model operating rules
- Uses observation and run-time input to define regulating rules
- Requires run-time interaction
- Total run-time control
- Quick to implement

SSARRESV Data Requirements

- Minimum Input
  - Elevation storage curve
  - Time series
    - Instantaneous inflow
  - Carryover
    - Instantaneous inflow and pool elevation at start of run
  - Run-time
    - SSARREG mod
- Additional Input
  - Data needed if used as part of 2 reservoir system or as reservoir or station with backwater effects

SSARRESV Operation Input

- The SSARRESV model is parameterized by providing an elevation storage curve and spillway rating curves.
- The reservoir operations are provided to the model via SSARREG runtime MODS.
- SSARREG Keywords:
  - FREEFLOW – free flow
  - SETQ – outflow specified
  - SETH – elevation specified
  - SETDQ – change in storage specified
  - SETDH – daily change in elevation specified
  - SETDS – daily change in storage specified

Use SSARR Operation when

- No operation rules or operator does not follow rules
- Reliable release data
- A single reservoir with or without backwater effects
- Two reservoirs with travel time between less than operation time interval
- Short or long term forecast

RES-J Operation Description

- Models either a single reservoir or a system of reservoirs.
- Uses topology information to describe the Tree-net (reservoirs, reaches and nodes) to be modeled.
- Reservoir system may be in parallel or in series.
- Solves the tree-net from upstream to downstream one time step at a time.
- Local flows to reaches and reservoirs should be generated before the RES-J operation so that they are available as tree-net inputs.

RES-J Operation Features

- Limited operating rules
- Requires little run-time interaction
- Some run-time control available
- Long implementation process

RES-J Data Requirements

- Minimum Input (at least one reservoir)
  - Elevation storage curve
  - Time series
    - Instantaneous inflow
  - Carryover
    - Instantaneous inflow and pool elevation at start of run
  - RULES – at least one method
- Additional Input
  - Data needed for multiple reservoirs

RES-J Input Organization

- Times series
- Topology
- Parameters
- Rules

RES-J Operation Input

- RES-J input method identifiers
  - ADJUST – reservoir output adjustment method
  - BALANCE – storage balancing for multi-reservoir system
  - LAGK – reach Lag and K routing method
  - MAXDECREASE – max daily decrease in reservoir discharge
  - MAXINCREASE – max daily increase in reservoir discharge
  - MAXSTAGE – downstream discharge control method
  - RAINEVAP – rainfall / evaporation on lake surface method
  - SETELEVATION – prescribed elevation method
  - SETMAX – select maximum element method
  - SETMIN – select minimum element method
  - SETRELEASE – prescribed release method
  - SETSUM – prescribed element summing method
  - SETWITHDRAW – prescribed withdrawal method

Use RES-J Operation when

- Have the operation rules
- Is single or multiple reservoirs without backwater effects
- Tree structured reservoirs in parallel or in series
- Short or long term forecasts

FLDWAV Operation Description(1)

- Models either a single reservoir or a system of reservoirs using level pool routing in the upstream reservoir and level routing or dynamic routing in the subsequent reservoir.
- When doing dynamic routing, cross section information is used to describe the river system (channel reaches and reservoirs).

FLDWAV Operation Description(2)

- Computes elevations and flows simultaneously at each location one time step at a time.
- All inflows (local flows and boundary flows) should be generated before the FLDWAV operation.
- Can handle subcritical and mixed flow condition.
- Can only be used to route uncontrolled flows (spillway, gate, and dam overtopping).

FLDWAV Operation Features(1)

- Models one or more reservoirs with or without backwater effect
- Models tree and bifurcation reservoir systems
- Models only reservoirs with uncontrolled flows
- Doesn’t model operating rules
- Requires little run-time interaction
- Some run-time control available

FLDWAV Operation Features(2)

- Requires somewhat extensive data input
  - May be used with a minimal amount of data and produce similar or better results than the level pool routing method;
    - average cross section (model interpolates)
    - constant n values

FLDWAV Operation Features(3)

- Long implementation process
  - A long implementation process is necessary when the model is calibrated for the purpose of generating information at the forecast points.
  - If the goal is to determine reservoir releases, short cut methods are applicable (not recommended)
  - The model is calibrated to a gage; with reservoir release info being a by-product of this process.

FLDWAV Data Requirements

- Minimum Input
  - Elevation-storage curve
  - Dam elevation, length, and weir coefficient
  - Spillway crest, length and weir coefficient
  - Gate centerline and opening
  - Turbine flow
  - Channel cross Sections
  - Upstream and downstream boundaries
  - Carryover - flow and stages for all channel sections at start of run
  - Run-time - none
- Additional Input
  - Data needed for multiple rivers and dams
    - flow and stages for all channel sections at start of run

FLDWAV Operation Input

- Number of rivers in the system
- Channel cross sectional data for all the rivers
- Upstream and downstream boundaries for all the rivers
- Parameters depict hydraulic characteristic of all the dams for all the rivers
- Channel flow regime
- Local flow

Use FLDWAV Operation when

- Do not have the operation rules
- Uncontrolled spillway release
- Have channel cross sectional data
- Allows for backwater effect
- Is tree or bifurcation river network
- Rapid rising or falling floods
- Short or long term forecasts
- Long reservoirs where level pool routing is not applicable

What to Do When You Have Little/No Information

- Dig / Ask questions
- Be creative
  - Derive info from other sources
  - Expertise from past experience
    - Make reasonable estimates
  - Use SSARRESV
  - Do you need to model it?

Comparison of Reservoir Models

	Reservoir system	Tree or network	Operation rules	backwater	Forecast Length
RES-SNGL	single	no	yes	no	Short and Long Term
SSARR	max two	Series	no	yes	Short and Long Term
RESJ	Single or multiple	Tree	yes	no	Short and Long Term
FLDWAV	Single or multiple	Tree & network	no	yes	Short and Long Term

Reservoir Operation Set up and Run

- All reservoir operations are fully integrated into NWSRFS
  - Defined in FCINIT or MCP3 programs
  - Available in calibration, forecast and ensemble streamflow prediction systems